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## (54) AN ELECTRICALLY CONDUCTIVE HOSE

(71) We, GUMMI EHLERS GMBH and CONTINENTAL GUMMIWERKE AKTIENGESELLSCHAFT respectively of 20 Gotenstrasse, 2000 Hamburg 1; and Continental-Haus, Postfach 169, 3000 Hannover, both Federal Republic of Germany; both German bodies corporate respectively, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

The invention relates to electrically conducting hoses, more especially for conveying fuels in fuelling plants, having reinforcing plies embedded in the walls of the hoses and external jackets made of rubber or rubber-like plastics material.

For fuel transfer on airfields and in oil docks, or on a smaller scale at petrol stations for road vehicles, according to the directives of relevant industrial associations, the use of electrically conductive hoses is prescribed to preclude the possibility of spark-flash-overs at the metal hose fittings as the result of static charges. For this purpose, according to known proposals, continuous metal conductor elements in the form of individual wires, meshes, cables, braids or the like may be embedded in the hose wall and connected at each of their ends to the end fittings of the hose. The direct metal current conduction ensures the maintaining of low resistance values substantially independently of the length of hose. On the other hand, the required good conductivity may, however, also have an adverse effect, if there is a possibility of contact being made with external current sources and under certain circumstances high-tension current flashes over into the hose. As shown by experience, the thin conductor elements subject to the heat of the current can then become so hot that they burn through the wall of the hose allowing the fuel passing through to spill out and ignite. This also applies in the case where the contact of the continuous metal conductors to the coupling fittings is produced via the weakly conductive outer hose jacket.

In contrast, therefore, the present aim is not to lower the passage resistance of fuelling hoses too far, and moreover, not to lower the resistance below the minimum resistance impermeable to high external currents. According to more recent safety regulations based on this knowledge fuelling hoses used at airports or even in the close proximity of electric railways and other high-tension installations a minimum resistance of $10^4$ ohms over a section of 1m length is required. This, however, implies a fundamental prohibition of metal inserts regardless of what type of hose is used. Since solutions in this direction can be realised only with the aid of semiconductors, the fulfilment of the more stringent safety regulations compels the complete renunciation of hitherto valid concepts.

It is possible, to render the rubber of the hose wall conductive by admixing carbon black, powdered metal, metal oxides or other loose particles in fine distribution. The conductive values obtainable according to this method, however, are limited and cannot be optionally increased, because the rubber with higher proportion of such conductive particles hardens and hoses made therefrom become bend-resistant and tend to be brittle. However, even if the prescribed passage resistance of $10^6$ ohms, as initial value, is successfully maintained, it has been found that this value is exceeded after a short period of use due to swelling of the elastomer hose material subject to the pressure of the liquids passing through, whereby the carbon black particles, as a consequence of molecular displacement, are spread apart and hence proper current conduction becomes questionable. Since moreover the internal rubber of fuelling hoses has to be particularly resistant to leaching, inclusion of carbon black in the wall region is prohibitive from the start. On the other hand, however, the outer rubber cannot contain excessive proportions of carbon black, because due to unavoidable frequent contact with oil and other lubricants during use it is subject to considerable swelling and its resistance can rise to a thousand times the value in a dry state.

A further problem arises when considering different lengths of hose, because even though it may be possible to obtain and maintain a resistance value of between $10^4$ and $10^6$ ohms for a relatively short hose of about 3 to 5m in length even for a long period, if the same construction is used for hose lengths of 30 m and over it can no longer provide the required minimum resistance values. It would also not be possible to shorten substantially a long hose produced with the required resistance value or to use it in separate sections without simultaneously lowering the resistance to an inadmissible extent.

The object of the invention is to set the electrical conductivity of fuel carrying hoses without using any metal elements to a dfined narrow tolerance region between $10^4$ and $10^6$ ohms independently of the length of the hose, and independently of swelling phenomena and other effects of use, and to retain this conductivity over the whole life of any hose within these limit values.

According to the present invention there is provided an electrically conductive hose, especially suitable for use for conveying fuels in fuelling plants, comprising textile reinforcing plies embedded in the wall of the hose formed by an inner and an outer jacket made of a rubber or rubber-like plastics material, a continuous intermediate layer being embedded in the wall of the hose between the inner and outer jackets and made of an electrically conductive elastomer the intermediate lawer having a maximum thickness equal to the thickness of the plies.

The intermediate layer may be produced, for example, from a rubber mixture highly filled with carbon black and having a resistance in the order of magnitude of 10 to $10^2$ ohms.cm, which is preferably applied to the outer surface of the reinforcing plies and adhesively connected thereto. It would, however, also be possible instead to accommodate the layer on the inner surface of the plies or locate it directly on the inner jacket of the hose wall adjacent the plies.

The conducting element in the hoses is formed by the intermediate layer as a bonding member between the textile plies and the outer rubber. The overall conductivity or the resistance value may be very accurately adjusted with the composition of the layer material taking into account the circumferential length of the hose cross-section in question. The intermediate layer is extremely thin relative to the thickness of the inner and outer jackets of the hose so that the unavoidable high degree of hardness of the intermediate layer does not have an adverse affect on the flexibility of the completed hose, and since it is materially bonded to the filaments of the reinforcing plies, the molecules of the layer and largely prevented from being mutually displaced. This protects them from excessive mechanical stretching and the danger of unnoticed breaks. The forming of the intermediate layer on the structure of the reinforcing plies also imparts thereto an undulating course deviating from the smooth-cylindrical shape, which has a favourable effect on the pliability and bending characteristics of the hose.

The initially set conductivity remains unaffected by the actions of the medium conveyed and of swelling phenomena in other regions of the hose wall. This conductivity may also be retained within the required tolerance limits for different lengths of hose, so that from a hose of considerable length, for example, 30 to 40m in length having the required resistance between $10^4$ and $10^6$ ohms, a substantially shorter section may be cut off and immediately used, it also having a resistance value within these limits, Joining of the hose ends requires neither any particular skill nor is it any more expensive than with known hoses. Accommodation of the conductice intermediate layer in the interior of the cross-section of the hose provides a measure of protection, since the existence both of the outer and the inner rubber jackets excludes the dangerous possibility of producing a connection having an excessively low resistance. If the outer rubber jacket has a substantially lower electric conductivity, $\sim 10^4$ ohm.cm, compared with the intermediate layer on the reinforcing plies, an electric semiconductor coupling can be readily produced with the pushing-on of the metal fittings. Similarly, the inner rubber jacket may instead be produced to be of low conductivity , $\sim 10^4$ ohms.cm, if, for example, the outer rubber jacket should have a special colouring of for other reasons not be made conductive.

The construction of the intermediate layer may be directed solely to the electrical requirements without consideration for the hardness of the material and its mechanical behaviour. For incorporation of the intermediate layer in the structure of the hose various methods may be applied depending upon the existing equipment used. Thus, for example the intermediate layer may be formed in an extrusion press and sprayed directly onto the mesh-covered or braided hose blank. Alternatively it could also be painted on in solution, wound helically as foil strip or band or rolled on the inside surface of the outer rubber jacket provided in the form of a sheet and applied together therewith in the hose blank. The invention is thus not restricted to a definite method of construction. The hardness of the intermediate layer considerably increases with the proportion of carbon black in the mixture, but this can be substantially disregarded due to the

extremely thin thickness of layer and the adhesive bonding directly with the outer filaments of the reinforcing plies. Therefore the invention fulfils the requirements demanded by multi-national oil companies for maximum safeguard and elimination of all sources of danger in the handling of liquid fuels.

Besides its electric properties the intermediate layer also has a favourable effect with regard to strength in that on account of its greater toughness it braces the hose against collapse when stressed by negative pressure. The greater resistance to crushing permits with the same wall thickness to be used with increased suction than conventional hoses or enables the wall thickness to be reduced for the same suction, which in turn results in lowering or production costs and minimizes weight. Since fuelling hoses in use usually have to be manually moved, these advantages are of particular significance.

The invention is not limited to fuelling hoses but applicable with advantage in all such cases in which a greater or lesser pronounced electric conductivity is demanded with simultaneous omission of metal inserts. Thus, for example, when carrying liquid gases it has been found that from the reaction of the liquids diffused into the wall of the hose, ammonia or the like, with the metal conductors, salts are formed, which in turn attack the fibres of the reinforcing plies and consequently can lead to destruction of the hose. This danger is overcome by the use of hoses in accordance with the invention.

WHAT WE CLAIM IS:—

1. An electrically conductive hose, especially suitable for use for conveying fuels in fuelling plants, comprising textile reinforcing plies embedded in the wall of the hose formed by an inner and an outer jacket made of rubber or rubber-like plastics material, a continuous intermediate layer being embedded in the wall of the hose between the inner and outer jackets and made of an electrically conductive elastomer, the intermediate layer having a maximum thickness equal to the thickness of the plies.

2. A hose as claimed in claim 1, in which the intermediate layer is made from a rubber mixture including carbon black and having an electric resistance in the order of magnitude of from $10^1$ to $10^2$ ohm.cm.

3. A hose as claimed in claim 1 or 2, in which the conductive intermediate layer is adhesively connected to the reinforcing plies.

4. A hose as claimed in claim 3, in which the conductive intermediate layer is applied to the outer surface of the reinforcing plies.

5. A hose as claimed in claim 3, in which the conductive intermediate layer is applied to the inner jacket of the hose wall adjacent to the reinforcing plies.

6. A hose as claimed in any of claims 1 to 5, in which the outer jacket is electrically conductive.

7. A hose as claimed in claim 6, in which the outer jacket of the hose has a substantially lower electric conductivity than the intermediate layer.

8. A hose as claimed in claim 7, in which the outer hose jacket has an electrical resistance of the order of magnitude of $10^8$ ohm.cm.

9. A hose as claimed in any of claims 1 to 5, in which the inner jacket of the hose wall is made from an electrically conductive rubber or plastics material.

10. A hose as claimed in claim 8, in which the inner jacket of the hose wall has an electrical resistance of the order of magnitude of $10^4$ ohm.cm.

11. An electrically conductive hose substantially as hereinbefore described.

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